

New palynological data on the age of the Kiltorcan Flora of Co. Kilkenny, Ireland

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ABSTRACT—The age of the fossil flora found in the Kiltorcan Formation of Co. Kilkenny has been disputed for many years, with no datable miospore assemblage ever being extracted from the plant beds due to the preservation. New exposure on Kiltorcan Hill, and experimentation with palynological techniques has allowed the extraction of two miospore assemblages. The palynological data studied shows that the strata on Kiltorcan Hill straddles the Devonian/Carboniferous Boundary; A Devonian LE Miospore Biozone assemblage has been examined from a plant bed with *Cyclostigma kiltorkense* whilst a Carboniferous VI Miospore Biozone date was determined for a plant bed with *Lepidodendropsis* sp., and? *Rhacophyton*. The topmost occurrence of *Cyclostigma kiltorkense* is unknown but it is certainly very near to the Devonian/ Carboniferous Boundary. The use of *Cyclostigma kiltorkense* as an index fossil for the uppermost Devonian is therefore not precluded.

GEOGRAPHICAL LOCATION OF EXPOSURE

Exposure at the classic Kiltorcan localities in County Kilkenny is limited to a few small quarries on Kiltorcan Hill (Fig. 1). The Old Plant Quarry (the “Classic Quarry” of Colthurst 1978) measures only 20 m by 6 m at maximum and is situated towards the top of Kiltorcan Hill, approximately 1.5 km ESE of Ballyhale village which lies on the main Waterford-Thomastown road, County Kilkenny. A wealth of work has been undertaken on the palaeontology of this locality which is now unfortunately almost entirely filled in. More extensive exposure now occurs 150 m to the north of the Old Plant Quarry in a network of disused Roadstone quarries, worked in the 1960’s and 1970’s. These cover a large area at the summit of Kiltorcan Hill (the “Council Quarry” of Colthurst 1978) and expose a seven to nine metre section of green and red siltstones and mudstones and yellow sandstones. A more recent exposure is to be found 100 metres to the south west of the Roadstone quarries. This has been termed the Kiltorcan New Quarry and was quarried during 1984–1985 where another short stratigraphic interval was exposed. This sequence underlies the Roadstone quarries and the two can be related by a section of intermittent exposure along a track (Fig.1).

PREVIOUS WORK ON AREA

Most interest in this area was originally concerned with the well preserved examples of plant fossils collected in the mid 19th Century from a small quarry on Kiltorcan Hill (the “Old Plant Quarry”). The first published work on the Kiltorcan locality was that of Forbes (1853); He described the 1851 discovery of the quarry, which was seen to “abound in fossils of great beauty and apparently entirely new”. The fossil fauna includes, *Archanodon jukesii* (Forbes) Howse (a freshwater bivalve), *Groenlandaspis disjectus* (Woodward) Ritchie (fish plates) and the arthropods *Belinurus* and eurypterids (Clayton *et al* 1980). More detailed work on the flora was carried out

by Chaloner, who (in Holland 1981) lists a floral assemblage including *Archaeopteris hibernica* (Forbes) Dawson, *Cyclostigma kiltorkense* Haughton, *Ginkophyllum kiltorkense* Johnson, *Sphenopteris hookeri* Baily and the seed *Spermolithus devonicus* Johnson. The fossil flora is very well preserved in chlorite and attracted much attention from palaeobotanists of the time [Baily (1861,1869), Griffith and Brongniart (1857, 1858) and Haughton (1855,1859). Much argument ensued as to the age of the flora. Griffith (op. cit), Haughton (op. cit), and others regarded the deposits as Lower Carboniferous, Forbes concluded a Devonian age, whilst Brongniart found the specimens were not sufficiently distinctive to enable him to decide between the two views.

No good miospore assemblage has ever been extracted from the strata on Kiltorcan Hill prior to the present study as the chlorite preservation of plant material does not aid the extraction of miospores with standard palynological techniques. Johnson (1913b) claims he observed miospores in material from the Old Plant Quarry. He experimented with some sporangia, treating them with schulze solution and ammonia, and obtained “many rounded bodies, some with triradiate mark” and concluded they were miospores. Chaloner (1968) was, however, unconvinced by Johnson’s miospores. He stated that “none of his (Johnson’s) preparations appear to have been preserved, and his photograph is rather unconvincing,” and concluded that “that the body Johnson observed and regarded as a microspore was either an artifact of preparation or a contaminant”. Chaloner (op.cit) examined megaspores on the surfaces of the sporangia of *Cyclostigma kiltorkense* concluding that they were similar to the dispersed genera *Lagnicula* and *Lagenosporites*. Yet he was unable to extract any miospore assemblages to indicate the the exact biostratigraphic level of the beds. A re-excavation of the Old Plant Quarry was made in the 1970’s, Chaloner *et al* (1977)

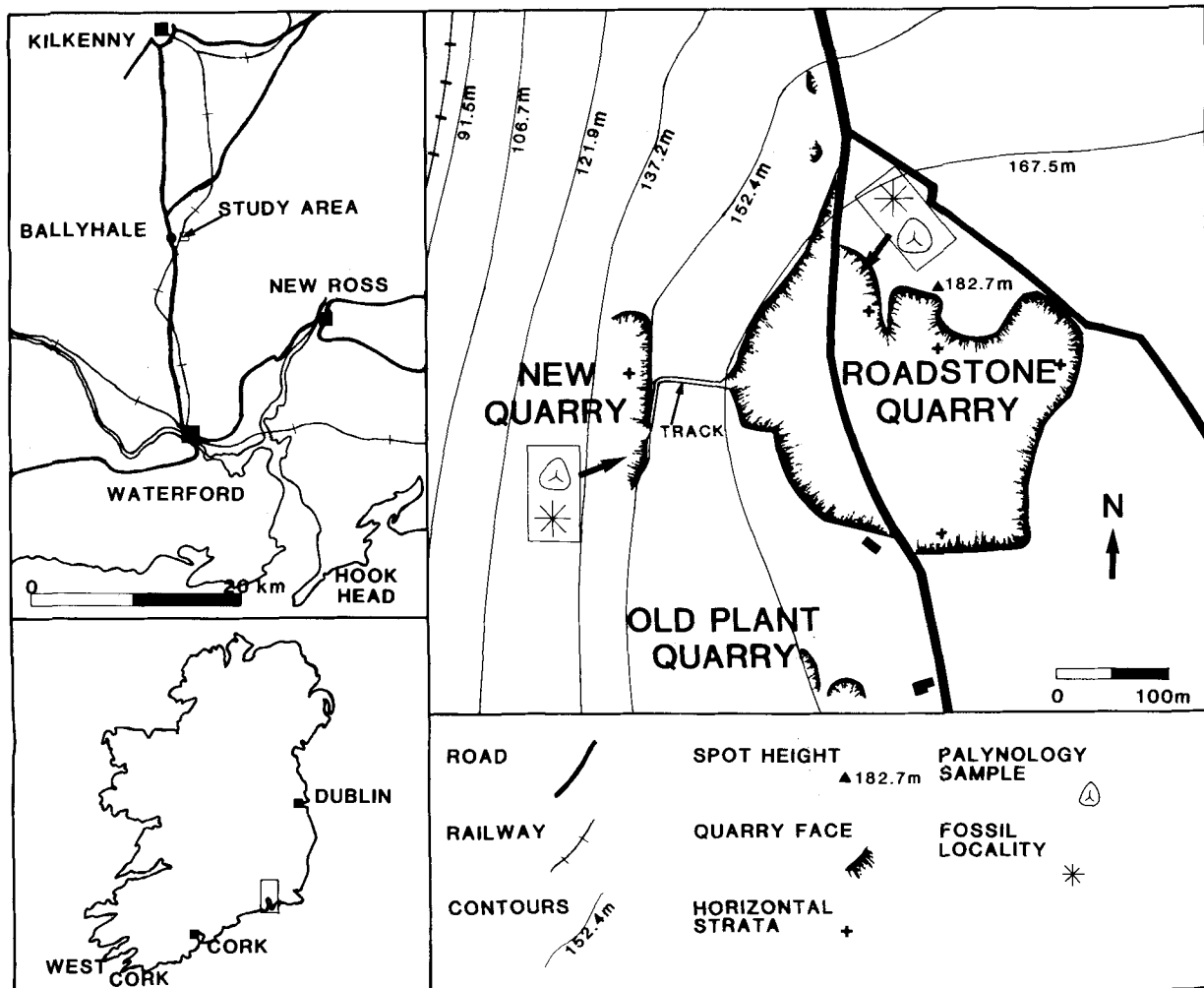


Fig. 1. Location map showing Kiltorcan Hill in County Kilkenny, Ireland, and the relationship between the sampled horizons.

described the discovery of seed *Spermolithus devonicus* during the re-excavation; This seed is important in the understanding of early gymnosperm evolution.

Clayton *et al* (1977) examined three palynological assemblages from the Kiltorcan Formation elsewhere in County Kilkenny. In this paper John Colthurst concluded that the sampled horizons were 40 and 50 m above the highest exposed levels on Kiltorcan Hill. Clayton *et al* (1977) suggest that the samples come from Carboniferous strata with an absence of *Retispora lepidophyta* correlating with the VI Miospore Biozone; Moreover, one of the higher samples contains *Spelaeotriletes balteaus* (Playford) Higgs, which suggests to the present author that the higher assemblage belongs to the higher BP Miospore Biozone of Higgs *et al* (1988) (Fig.3).

EXPOSURE DESCRIPTION AND SAMPLED HORIZONS

The Kiltorcan Formation is the highest division of the Old Red Sandstone facies (O.R.S.) in S. E. Ireland. The sediments

of the Kiltorcan Formation exposed on Kiltorcan Hill consist mainly of siltstone and fine sandstone with laterally extensive coarse sandstone bodies occurring at two horizons. Fine grained arenaceous rocks show both vertical and lateral gradation between red and green colouration. Plant material is found in most of the green coloured sediment; there are, however, a number of horizons where plant material is especially common. These are: (1), at the base of the succession in the New Quarry, (2), the Old Plant Quarry and (3), in the northern part of the Roadstone Quarry. The Plant Quarry horizon contained both *Archaeopteris hibernica* and *Cyclostigma kiltorkense* whilst only *C. kiltorkense* is present at the New Quarry horizon. The floral assemblage collected from the Roadstone Quarry includes *Lepidodendropsis* spp. aff. *L. hirmeri*, cf. *Rhacophyton* spp. and the alga *Bythotrephix* spp. (pers. comm. W. S. Lacey 1989). Preservation in the Roadstone and Old Plant Quarries is by chloritisation whilst the New Quarry horizon shows coalified preservation. Palynology samples were collected from the New Quarry plant bed (sample 88/1) which is estimated to be some 20m

below the floor of the Old Plant Quarry, and from the Roadstone Quarry (sample CQ1) an estimated 4 or 5m above the topmost strata in the Old Plant Quarry.

PREPARATION TECHNIQUES

Numerous attempts were made by the author to extract a productive palynological sample from the plant beds in the Roadstone Quarry. Best results were obtained by collecting large amounts of thinly laminated dark grey mudstone found within green siltstone. These were then crushed and chemically broken down by hydrofluoric acid. The resulting residue was then subjected to prolonged boiling in hydrochloric acid to remove the large amounts of flourides present. The organic residue obtained was small but contained a diverse and well preserved palynoflora. Samples from Kiltorcan New Quarry only required standard palynological techniques to produce a very rich residue. The palynological assemblages studied from both samples display lower levels of organic maturity than samples observed from similar horizons in the Kiltorcan Formation elsewhere in Southern Ireland. Thermal alteration index (TAI) values (Staplin 1982) in the order of 3, with a spore colour of dark yellow to orange brown (of Pearson 1984) were noted in unoxidised material. Oxidation times with Schulze Solution were limited to 1 hour for the New Quarry and 30 minutes for the Roadstone Quarry samples. Permanent scatter mounts were made using Cellulize as a dispersing agent and Elvacite as a cold mounting medium. These slides are housed in the Micropalaeontological collection of the Department of Geology, U.C.C.

PALYNOLOGY RESULTS

The palynological slides produced were carefully scanned for important stratigraphic forms and new species, systematic counts of 500 specimens were made for both samples. Undescribed species will be examined in a later paper. The preliminary results are shown below. The range of each species within the Miospore Biozones of the Tournaisian of Ireland is given after Higgs *et al* 1988. See Fig. 3 for Miospore Biozones.

SAMPLE 88/1.

LOCATION Kiltorcan New Quarry southern end.

HORIZON 20m below Old Plant Quarry.

LITHOLOGY Grey Siltstone.

ASSOCIATED PLANTS *C. kiltorkense*, stems up to 7 cms wide and 14 cms length. Rootlets in bed below.

NEW QUARRY SAMPLE ASSEMBLAGE LIST

<i>Apiculiretusispora fructicosa</i> Higgs	LL- CM
<i>Auroraspora macra</i> Sullivan	LL- CM
<i>Auroraspora solisortus</i> Hoffmeister Staplin & Malloy	LL- CM
<i>Dictyotriletes trivialis</i> Naumova in litt. Kedo	LE- CM
<i>Corbulispora cancellata</i> (Waltz) Bharadwaj & Venkatachala	LL- CM
<i>Diducites mucronatus</i> (Kedo) emend Van Veen	LL- VI
<i>Diducites plicabilis</i> VanVeen	LL- LN
<i>Diducites versabilis</i> (Kedo) emend Van Veen	LL- LN
<i>Endoculeospora gradzinskii</i> Turmaw	LE- CM

<i>Grandispora echinata</i> Hacquebard	LL- CM
<i>Grandispora cf. echinata</i> Hacquebard	LL- VI
<i>Hymenozonotriletes explanatus</i> (Luber) Kedo	LL- PC
<i>Plicatispora scolecophora</i> (Neves & Ioannides) Higgs, Clayton & Keegan	LL- CM
<i>Punctatisporites irrasus</i> Hacquebard	LL- CM
<i>Pustulatisporites cf. dolbii</i> Higgs, Clayton & Keegan	LL- PC
<i>Raistrickia cf. macrura</i> (Luber) Dolby & Neves	LL- PC
<i>Raistrickia variabilis</i> Dolby & Neves	LL- CM
<i>Retispora lepidophyta</i> (Kedo) Playford	LL- LN
<i>Retispora macroreticulata</i> (Kedo) Byvscheva	LL- LE
<i>Retusotriletes planus</i> Dolby & Neves	LL- PC
<i>Rugospora flexuosa</i> (Jushko) Streel	LL- LN
<i>Spelaeotriletes crenulatus</i> (Playford) Higgs, Clayton & Keegan	LL- CM
<i>Velamispores caperatus</i> (Higgs) Higgs, Clayton & Keegan	LL- LN

QUANTITATIVE ANALYSIS

% of total based on count of five hundred specimens.

<i>Retispora lepidophyta</i>	= 66.3%
<i>Diducites</i>	= 1.9%
<i>Rugospora flexuosa</i>	= 4.3%
<i>Hymenozonotriletes explanatus</i>	= 1.6%
Others	= 25.9%

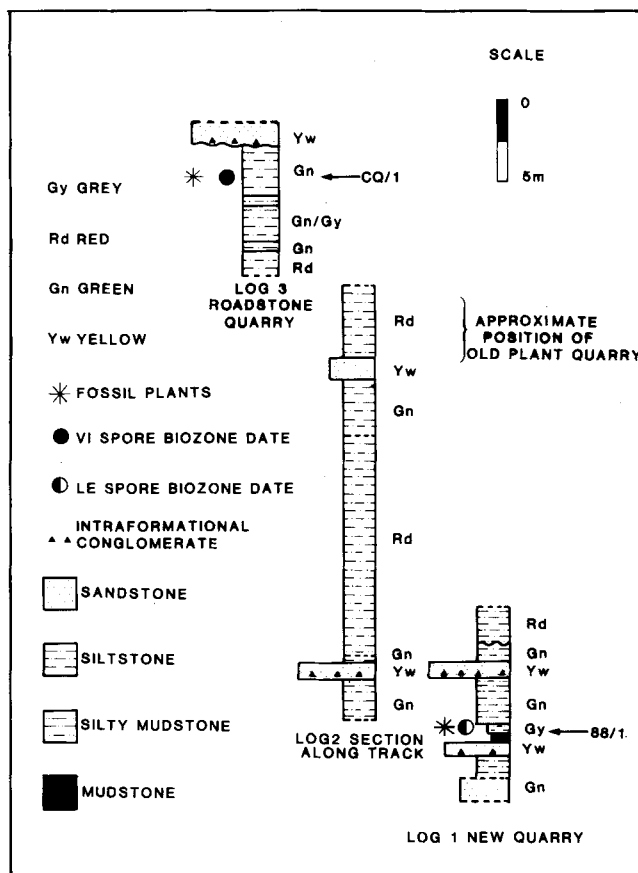


Fig. 2. Graphic logs showing the succession on Kiltorcan Hill and the location of productive palynology samples.

SAMPLE CQ1

LOCATION Kiltorcan Roadstone Quarry, northern end.

HORIZON 5m above Old Plant Quarry.

LITHOLOGY Dark grey fine siltstone and mudstone laminae in green siltstone and fine sandstone unit

ASSOCIATED PLANTS *Lepidodendropsis* spp., and ?*Rhacophyton*. Mostly *Lepidodendropsis* spp. stems up to 2 cms wide and 15 cms long; some current alignment.

ROADSTONE QUARRY SAMPLE ASSEMBLAGE LIST

<i>Apiculiretusispora fructicosa</i> Higgs	LL- CM
<i>Auroraspora asperella</i> (Kedo) Van der Zwan	LN- CM
<i>Auroraspora corporiga</i> Higgs, Clayton & Keegen	VI- PC
<i>Bascaudaspora collicula</i> (Playford) Higgs, Clayton & Keegan	LL- PC
<i>Convolvitispora vermiformis</i> Hughes & Playford	LL- CM
<i>Cymbosporites minutus</i> (Kedo) Avchimovitch & StreeI	LL- PC
<i>Dictyotriletes trivialis</i> Naumova in litt. Kedo	LE- CM
<i>Grandispora</i> spp.	LL- PC
<i>Kraeuselisporites fasciatus</i> Higgs	LL- PC
<i>Knoxisporites literatus</i> Waltz (Playford)	LL- CM
<i>Knoxisporites triangularis</i> Higgs, Clayton & Keegen	VI- CM
<i>Leiotriletes trivialis</i> Naumova	LL- VI
<i>Plicatispora quasibrata</i> (Neves & Ioannides) Higgs, Clayton & Keegen	LL- CM
<i>Retusotriletes incohatus</i> Sullivan	LL- CM
<i>Retusotriletes triangulatus</i> (StreeI) StreeI	LL- PC
<i>Spelaeotriletes obtusus</i> Higgs	VI- BP
<i>Spelaeotriletes resolutus</i> Higgs	VI- PC
<i>Verrucosisporites nitidus</i> (Naumova) Playford	LN- CM
<i>Vallatisporites vallatus</i> Hacquebard	VI- CM
<i>Vallatisporites verrucosus</i> Hacquebard	LL- CM

QUANTITATIVE ANALYSIS

% of total based on count of five hundred specimens.

<i>Spelaeotriletes</i> spp.	= 5.9%
<i>Verrucosisporites nitidus</i>	= 2.6%
<i>Vallatisporites vallatus</i>	= 0.8%
Others, mostly acamerate weakly ornamented forms	=90.7%

STRATIGRAPHIC IMPLICATIONS.

Higgs *et al* (1988) published a palynostratigraphical zonation for the Tournaisian rocks of Ireland (Fig3). In this zonation the LL, LE and LN Miospore biozones belong to the "Strunian" (Upper Devonian) part of the Tournaisian. The VI Spore Biozone and higher Biozones belong to the lowermost Carboniferous. The assemblages recorded can be correlated with this miospore zonation scheme. The lowest sample studied, 88/1, contains abundant amounts of *Retispora lepidophyta* which together with the presence of other biostratigraphically important forms such as *Rugospora flexuosa*, *Diducites plicabilis* and *Diducites versabilis* indicate a Devonian age for this sample. The presence of *Hymenozonotriletes explanatus* and the absence of *Verrucosisporites nitidus* and *Vallatisporites verrucosus* indicate the assemblage belongs to the LE Miospore Biozone suggesting a Strunian early Tnlb age.

In contrast, the palynological assemblage extracted from

the plant beds in the Roadstone Quarry contains no *Retispora lepidophyta*, *Rugospora flexuosa* or *Diducites versabilis*. Moreover, *Verrucosisporites nitidus* is present and *Spelaeotriletes obtusus* and *Spelaeotriletes resolutus* were found in high percentages. These combined factors indicate the assemblage belongs to the VI Biozone, whilst the the absence of *Kraeuselisporites hibericus* and *Umbonatisporites distinctus* indicates the age to be lowermost Courceyan, late Tnlb.

It therefore appears that the Devonian/Carboniferous Boundary occurs within the 25m between the two study horizons.

PALAEOENVIRONMENTAL IMPLICATIONS

Van der Zwan and Van Veen (1978) and Van Veen (1981) working on sections of uppermost O.R.S in West Cork and Hook Head (Fig.1) made palaeogeographical reconstructions from the distribution of selected miospore taxa. Van Veen (1982) concluded that *Diducites* was related to an alluvial plain environment whilst *Retispora lepidophyta* was related to a coastal area environment in LN and LE Biozone times. He does, however, go on to state that "the regional and interregional implications of such environmentally controlled dominances can only be estimated when comparable data from other sections are available"

Comparison of Van Veen's model with data from the present study is unfavorable. Palaeoenvironmental conditions for the New Quarry strata are interpreted as humid alluvial plain, however, *Retispora lepidophyta* is found in great amounts comprising 66.3% of the total palynological assemblage, whilst *Diducites* only makes up 1.9% of the same. Van Veen's (op. cit.) model would suggest the high percentage of *R.lepidophyta* was due to deposition on a coastal plain environment, this is not so in the case in hand. However, the presence of *R.lepidophyta* in large percentages does appear to be related to a palaeoenvironmental factor. Sedimentological analysis of the Kiltorcan Formation at this locality suggest that the sediments were laid down on a humid, wet floodplain. These conditions may have been much more water saturated than the conditions under which the O.R.S. alluvial plain sediments elsewhere in Southern Ireland were deposited. Moreover, humidity and water saturation levels in the coastal plain O.R.S. environments Van Veen (op.cit.) studied may have been much closer to those of the Kiltorcan Formation. Thus the high percentages of *R.lepidophyta* in the uppermost O.R.S. could represent conditions of high humidity and water saturation at the time of deposition. The relative percentages of *Diducites* and *R.lepidophyta* in late Devonian palynological assemblages may therefore prove to be an indicator of humidity and water saturation of environment rather than a palaeogeographical indicator.

BIOSTRATIGRAPHICAL IMPORTANCE OF THE MEGAFLORA

In terms of dating the macroplant beds the palynological

		SPORE BIOZONE	SELECTED SPECIES RANGE BOTTOMS	SELECTED SPECIES RANGE TOPS	
CARBONIFEROUS (Courceyan)	TOURNAISIAN Tn2b	PC	<ul style="list-style-type: none"> <i>Spelaeotriletes pretiosus</i> <i>Raistrickia clavata</i> 	<ul style="list-style-type: none"> <i>Spelaeotriletes resolutus</i> <i>Spelaeotriletes obtusus</i> 	
		BP	<ul style="list-style-type: none"> <i>Spelaeotriletes balteatus</i> 		
		HD	<ul style="list-style-type: none"> <i>Umbonatisporites distinctus</i> <i>Krauselisporites hibernicus</i> 		
	DEVONIAN (Strunian)	TOURNAISIAN Tn1b	VI	<ul style="list-style-type: none"> ROADSTONE QUARRY CQ/1 <i>Spelaeotriletes obtusus</i> 	<ul style="list-style-type: none"> <i>Retispora lepidophyta</i> <i>Rugospora flexuosa</i> <i>Diducites versabilis</i>
			LN	<ul style="list-style-type: none"> <i>Verrucosisporites nitidus</i> <i>Vallatisporites verrucosus</i> 	
		Tn1	LE	<ul style="list-style-type: none"> NEW QUARRY 88/1 	
			Tn1a-b	LL	

Fig. 3. Miospore biozones for the Tournaisian of Ireland (after Higgs *et al* 1988). With stratigraphic positions of dated horizons in present study.

results indicate that the *Lepidodendropsis* spp. and the cf. *Rhacophyton* spp. flora is restricted to Carboniferous strata, whilst the only dated horizons with *Cyclostigma kiltorkense* are Devonian. However, the range top of *Cyclostigma kiltorkense* is problematical, the horizons which contain *C. kiltorkense* are at least 20 m apart and only the lower horizon is dated as belonging to the LE Miospore Biozone. In contrast the plant assemblage in the Roadstone Quarry some 5 m above the upper occurrence of *C. kiltorkense* yielded a lowermost Carboniferous (VI Spore Biozone) age. The exact level of the Devonian/Carboniferous Boundary therefore remains unknown. The abrupt change in floral assemblage between the Old Plant Quarry and the Roadstone Quarry appears to be significant, the lower flora of the Old Plant Quarry may be Devonian whilst the upper plant bed in the Roadstone Quarry is definitely lowermost Carboniferous. I would therefore tentatively suggest that *Cyclostigma kiltorkense* and *Archaeopteris hibernica* are restricted to the Upper Devonian at Kiltorcan Hill with their probable range tops in the LE or the LN Miospore Biozones. No unequivocal evidence is available due to the lack of suitable sample horizons in the Old Plant Quarry, but it may be the case that the Devonian/Carboniferous Boundary occurs within the red silt between the Old Plant Quarry and the Roadstone Quarry.

Fairon-Demaret (1986) made a stratigraphical review of

uppermost Devonian megafloras. In that paper discussion as to the time-restricted distribution of *Cyclostigma kiltorkense* was given. Occurrences of *C. kiltorkense* outside Southern Ireland are rare; Fairon-Demaret (op. cit) discusses floral assemblages including *C. kiltorkense* from Bear Island and Siberia (Schweitzer 1969) and South and Southeastern China (Li Xingxue *et al* 1984, and Huang Da-Xin 1978). Kaiser (1970) examined palynological assemblages from the *C. kiltorkense* bearing sequence at Bear Island, the present author's interpretation of Kaiser's (1970) assemblage list suggests the flora at Bear Island is preserved in Devonian strata from the LE Miospore Biozone. Palynological dates from these sections, therefore, suggest that *C. kiltorkense* could be restricted to the Strunian. Fairon-Demaret (op. cit) suggested that the stratigraphically restricted record of *C. kiltorkense* is indicative of its index value for an upper subzone in Bank's floral assemblage VII (Banks 1980). However, Fairon-Demaret (op. cit) also notes that precise dating of the Kiltorcan Hill horizon is needed before absolute conclusions are to be drawn.

The palynological evidence from the present study adds support to the suggestion that *Cyclostigma kiltorkense* on Kiltorcan Hill could possibly be restricted to the Strunian. Fairon-Demaret (op. cit) also notes that the range top of the genus *Archaeopteris* is unknown "with its persistence in the

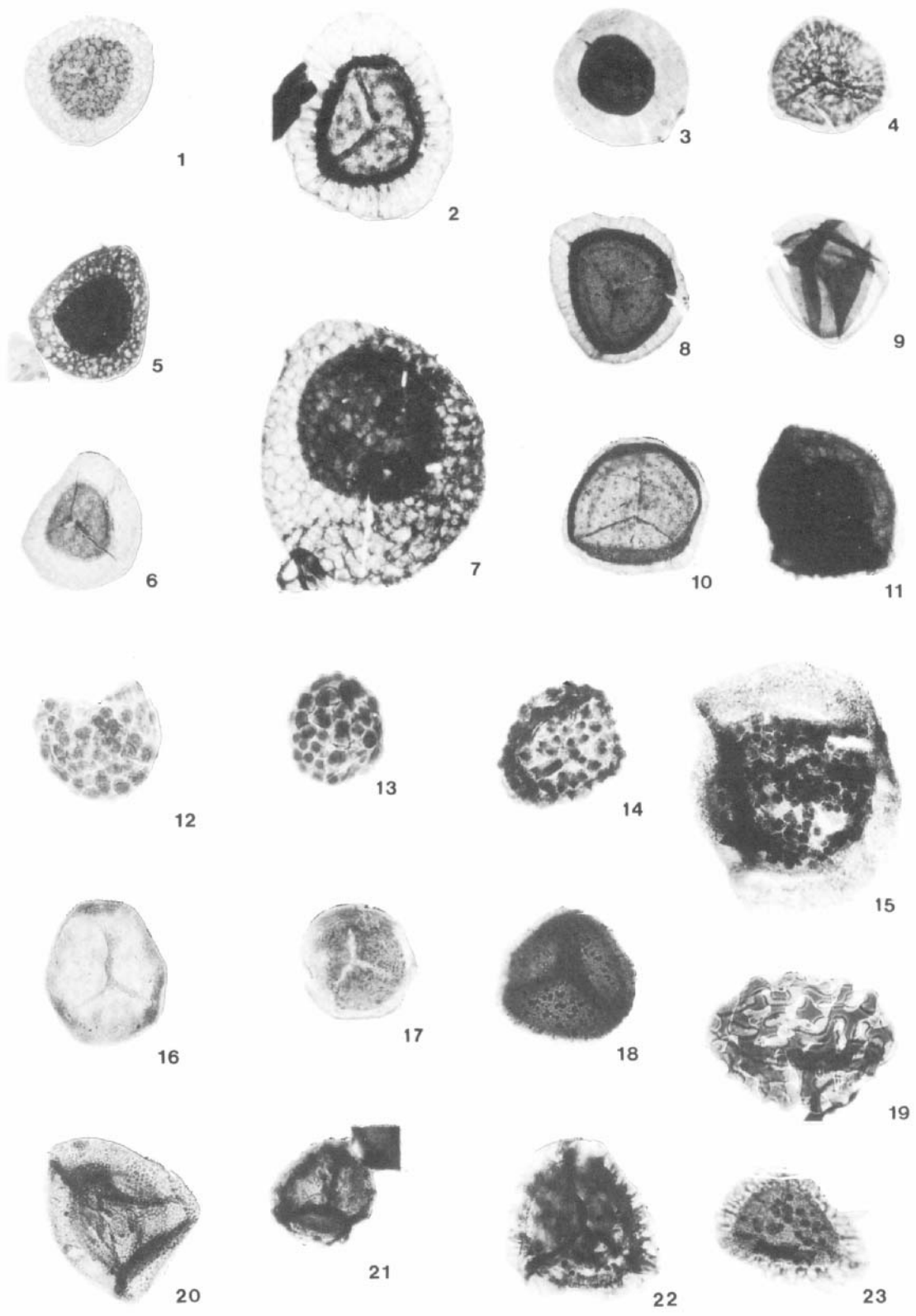
Explanation of Plate 1 All Magnifications x 420

FIGS. 1–11 UPPER DEVONIAN (STRUNIAN) ASSEMBLAGE

Fig. 1.	<i>Retispora lepidophyta</i>	88/1–1	V37
Fig. 5.	<i>Retispora lepidophyta</i> Unoxidised	88/1–0	U30/4
Fig. 6	<i>Retispora lepidophyta</i>	88/1–3	E55
Fig. 2	<i>Vallatisporites pussillites</i>	88/1–A	U24/4
Fig. 3.	<i>Auroraspora solisortus</i>	88/1–A	W12/2
Fig. 4.	<i>Rugospora flexuosa</i>	88/1–3	B44/3
Fig. 7	<i>Retispora macroreticulata</i>	88/1–A	L9/4
Figs. 8 & 10	<i>Hymenzonotriletes explanatus</i>		
Fig. 8	<i>Hymenzonotriletes explanatus</i>	88/1–A	W24/4
Fig. 10	<i>Hymenzonotriletes explanatus</i>	88/1–3	C37/4
Fig. 9.	<i>Diducites polijessicus</i>	88/1–A	W24/3
Fig. 11	<i>Diducites versabilis</i>	88/1–3	C37/4

FIGS. 12–23 LOWER CARBONIFEROUS ASSEMBLAGE

Fig. 12	<i>Verrucosisporites nitidus</i>	CQ1–A	V26
Fig. 13	<i>Verrucosisporites nitidus</i>	CQ1–E	E13
Fig. 14	<i>Cymbosporites minutus</i>	CQ1–B	E17/1
Fig. 15	Spore type A	CQ1–G	R11
Fig. 16	<i>Retusotriletes incohatus</i>	CQ1–B	J41/2
Fig. 17	<i>Auroraspora corporiga</i>	CQ1–G	039/4
Fig. 18	<i>Spelaeotriletes resolutus</i>	CQ1–B	N27
Fig. 19	<i>Convolutispora vermiformis</i>	CQ1–B	L24/4
Fig. 20	<i>Spelaeotriletes obtusus</i>	CQ1–A	S12/4
Fig. 21	<i>Bascaudaspora collicula</i>	CQ1–E	N20/1
Fig. 22	<i>Vallatisporites vallatus</i>	CQ1–E	H3/2
Fig. 23	<i>Vallatisporites vallatus</i>	CQ1–G	P34



Lower Carboniferous still depending on precise dating of critical localities as in the New Albany Shale and in the Kiltorcan Formation". From the present study it appears that the occurrence of *Archaeopteris hibernica* on Kiltorcan Hill could also be restricted to the Devonian.

Chaloner *et al.* (1977) described a seed *Spermolithus devonicus* from the Kiltorcan Old Quarry. This seed was suggested to be the first Devonian platyspermic seed. It should be noted that a Devonian age for this seed is not precluded.

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